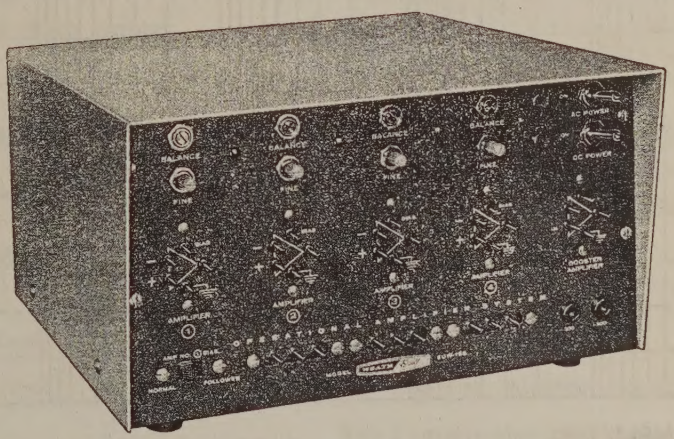
OPERATION OF THE HEATH OPERATIONAL AMPLIFIER SYSTEM

MODEL EUW-19B



CONTENTS

Specifications. 2
Introduction. 4
Operation. 4
Sample Operational Amplifier Circuits. 8
Replacement Parts. 12
Circuit Description. 13
Schematic . . . . . (fold-out from page). 15
Replacement Parts Price List. 16

MP MASTER
MA22741

HEATH COMPANY
BENTON HARBOR, MICHIGAN

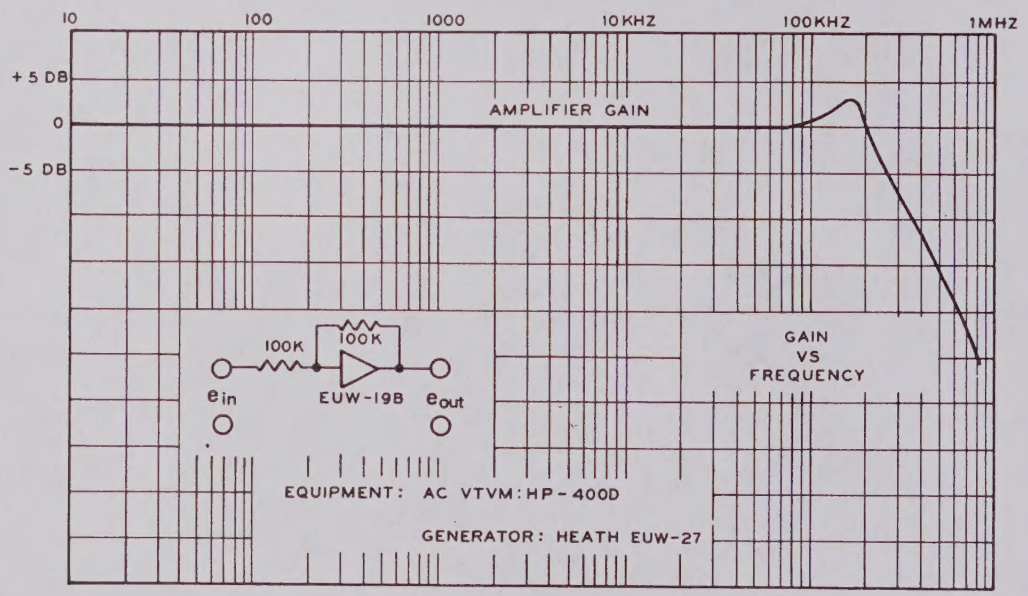
595-820

Copyright © 1966
Heath Company
All rights reserved

12-8-67

SPECIFICATIONS

Contents of System. . . . . Four Differential Input Operational Amplifiers.
One Booster Amplifier.
One DC+ Power Supply, regulated.
One DC- Power Supply, regulated.



OPERATIONAL AMPLIFIERS

DC Gain, Open Loop. . . . . 21,000 (87 db), typical.

Frequency Response. . . . . See curve.

Output Voltage Range. . . . . -50 V DC to +50 V DC, minimum.

Output Current Range. . . . . -1 ma to +1 ma with 50 KΩ load.

Output Impedance. . . . . Less than 1.5 Ω (with 1:1 feedback as shown).

Rise Time. . . . . 12 μ sec (with 1:1 feedback as shown).

Drift. . . . . Less than ±5 mv/8 hr. day referred to the input under controlled room temperature and line voltage conditions after 48 hours, or more, aging period.

Bias Supplies. . . . . 4 - one for each amplifier for DC Zero adjustment. Amplifier No. 1 Bias is switch selected for follower or inverter operation.

BOOSTER AMPLIFIER

Maximum Current Output.	±20 ma.
Maximum Voltage Output.	±50 V DC.
Gain.	Approximately 0.8.
Output Impedance.	Less than 0.2 Ω.

+300 V AND -300 V REGULATED POWER SUPPLIES

DC+ Output Voltage Range.	Regulated +280 to +320 volts (approximately).
DC- Output Voltage Range.	Regulated -280 to -320 volts (approximately).
Voltage Regulation (Each Supply).	Output variation less than 1% from no load to full load at 300 volts. Output variation less than ±1 volt for a ±10 volt variation in the AC line input.
Ripple Voltage (Each Supply).	Less than 10 millivolts rms ripple, jitter, and noise.
Output Impedance (Each Supply).	Less than 10 Ω from 5-100,000 Hz (cps).

POWER REQUIREMENTS

AC Input.	105-125 volts, 50/60 Hz (cps). (210-250 volts, optional.)
Filament Power Only.	44 watts.
Total Power Required.	104 watts at quiescent operating conditions.
Fuses.	Two 1 ampere slow-blow fuses; one for the filament circuits and auxiliary AC output, and one for the DC+, DC- supply and fan motor.

AUXILIARY POWER CONNECTOR

Location.	Octal socket on rear of unit, and banana jacks on front panel.
Power Available.	+300 volts at 20 ma and -300 volts at 20 ma with unit in operation. +300 volts at 60 ma and -300 volts at 60 ma when all amplifier tubes are removed. 6.3 volts AC at 50 ma with unit in operation. 6.3 volts AC at 3.2 amperes with all amplifier tubes removed.

AC VOLTAGE SOCKETS

Location.	On rear of unit.
Power Available.	117 volts, 15 watts maximum.

GENERAL

Dimensions.	11-1/4" wide x 6-3/8" high x 10-1/2" deep.
Net Weight.	17 lbs.

INTRODUCTION

The Heath Model EUW-19B self-contained Operational Amplifier System can be used both for classroom experiments and for experimental work in research and development laboratories. The System incorporates each of the following units on a single, compact chassis; four high-gain differential input operational amplifiers; four bias supplies for DC zero adjust; a high-current booster amplifier; and regulated +300 volt and -300 volt power supplies. One of the bias supplies can be switched for use with an inverting amplifier or a follower amplifier. An auxiliary power connector at the rear of the unit, and two jacks on the front panel make available +300 and -300 volts, regulated, to operate auxiliary equipment. 6.3 volts and 117 volts AC are also available at the power connector and AC socket at the rear of the unit. The entire unit is forced-air cooled with a fan for maximum stability.

The high-gain, low drift, and wide flexibility of this unit makes it extremely useful in measurement, control, and computation applications. The nature of each application is determined by how the feedback connections are made to the front panel and also by what types of external devices are used with the amplifier. Some of the ways the system may be used in laboratories are: As a constant current source; as a constant potential source; as a linear sweep generator; or as a servo system simulator. Addition, subtraction, integration, and differentiation problems can also be programmed on the unit.

The Heath Operational Amplifier Stabilizer Model EUA-19-4 can be plugged directly onto the front panel with no physical or electrical changes. This unit decreases the drift to ±0.5 mv/day and increases the DC open-loop gain to 21,000,000 for all operational amplifiers.

The input and output connections of the amplifiers are arranged so either the quick-connect parts of the Model EU-13A Universal Experimental kit, or standard 5-prong tube sockets can be fastened on the front panel. The Heath Model EUA-19-2 Polarography Module can also be plugged directly onto the front panel of the Operational Amplifier with or without the EUA-19-4 Stabilizer.

Blank chassis modules for plug-on connection to individual amplifiers or for all five amplifiers are available from Heath Company. These modules can be used to conveniently construct and connect external circuitry to the Operational Amplifier. The Model EUA-19-3 consists of five separate chassis that can be used individually or bolted together. The Model EUA-19-1 is a single chassis module with five sockets that can be plugged onto the front of the Operational Amplifier.

The instrument is one of the units included in the Malmstadt-Enke EU-100A Instrumentation Laboratory. It is available as an individual unit, or it can be purchased at a special group price when included with the total EU-100A System. The units of the complete EU-100A Laboratory Station are useful not only in learning electronic concepts, but also in research and development, and control instrumentation.

NOTE: This manual uses the new IEEE (Institute of Electrical and Electronic Engineers) and international standard term "hertz" as the basic unit of frequency. The terms are used as follows:

Hz (hertz) = cps (cycles per second).
kHz (kilohertz) = kc (kilocycles per second).
MHz (megahertz) = mc (megacycles per second.

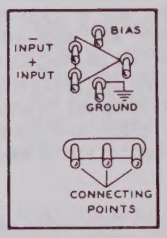
OPERATION

FRONT PANEL

Refer to Figure 1 for the following paragraphs.

NOTE: This Operational Amplifier System may be wired internally for use on power line voltages of 105-125 VAC, or 210-250 VAC, 60 Hz (cps). Be sure the line voltage in your area is correct for the way your unit is wired.

1. Connect the line cord to an AC outlet. Turn the AC POWER switch ON; this applies power to all filaments and to the AC POWER lamp. To obtain maximum stability, allow the unit to warm up for one-half hour before putting it into operation.
2. Turn the DC POWER switch ON. This applies B+ voltage to all circuits and also turns on the fan motor.



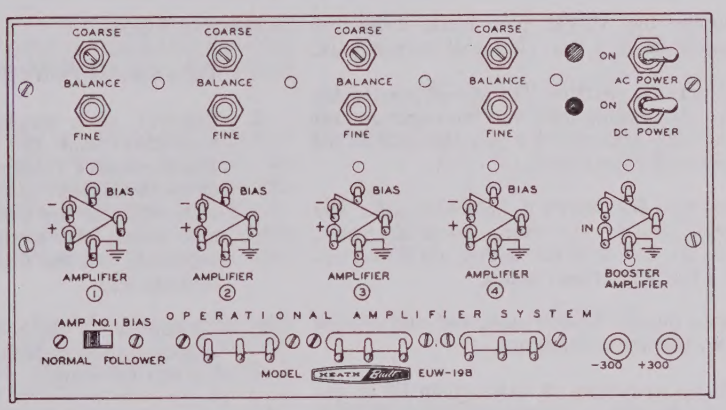


Figure 1

NOTE: The fan draws air through the slots in the bottom of the chassis and exhausts it out the rear panel. Never operate the Operational Amplifier System with the bottom of the chassis or rear panel blocked, since this would restrict the air flow.

WARNING: Under certain conditions, high voltage may be present at the Amplifier pins on the front panel. The safest procedure is to turn the DC POWER switch OFF when making connections to these pins. If it is necessary to make connections with the DC POWER ON, be sure to touch the unit with only ONE HAND to minimize the danger of electrical shock.

All four operational amplifiers have differential inputs. Both inverting (-) and noninverting (+) inputs are available at the front panel posts. See Figure 1. For normal inverting amplifier operation, the (-) input is active and the adjustable bias supply at the bias pin is connected to the (+) input to provide the zero adjustment. All four amplifiers may be used as followers or in other circuits with an active (+) input if the bias is omitted or if an external bias source is used. Amplifier #1 may be used as a follower with its internal bias supply. To accomplish this, switch the Amplifier No. 1 BIAS switch to FOLLOWER and connect the bias pin to the (-) input. The signal source is connected to the (+) input.

Connections can be made to the Amplifier pins on the front panel with the quick-connect parts of the Experimental kits, Models EU-13A and EU-14A. A standard 5-prong tube socket can also be plugged directly onto the Amplifier pins.

The 3-pin terminals near the bottom of the front panel are not connected in the system. These lugs provide convenient connecting points for the other end of parts connected to the Amplifier terminals.

POWER SUPPLY ADJUSTMENT

Refer to Figure 2 (fold-out from Page 7) for the following paragraphs.

A screwdriver adjust control which is located on the chassis, adjusts the voltage of the +300 volt and -300 volt power supplies. It will be necessary to remove the Cabinet from the unit to reach this control.

The +300 and -300 volt power supplies are adjusted at the factory. However, if readjustment is found necessary, reset the Voltage Adjust control by performing the following procedure.

NOTE: Allow the unit to warm up for one-half hour before making these adjustments.

CAUTION: When connecting to the -300 and +300 volt outputs, be sure the DC POWER switch is in the OFF position, since there is 600 volts between the -300 and +300 volt outputs.

1. Connect the positive test lead of an accurate VTVM, set to read +300 volts or higher, to the ground ($\perp$) pin on the BOOSTER AMPLIFIER terminal. Connect the negative VTVM test lead to the -300 volt output jack.

2. Turn the DC POWER switch to ON and adjust the VOLTAGE ADJUST control carefully until the VTVM reads exactly 300 volts. Turn the DC POWER switch to OFF.

3. Remove the VTVM test leads from the ground pin and the -300 volt output jack.

4. Connect the positive VTVM test lead to the +300 volt output jack and the negative test lead to the ground (⏚) pin of the BOOSTER AMPLIFIER terminals.

5. Turn the DC POWER switch to ON. The VTVM should read within 1% of 300 volts. Turn the DC POWER switch OFF and remove the VTVM test leads.

The Power Supply is now adjusted and should require no further adjustment.

NOTE: If an accuracy of better than 1% is required, a resistor in series with Rx (see Schematic, fold-out from Page 15) will lower the +300 volts, while a resistor in parallel with Rx will raise the +300 volts. By experimentally changing the resistor in series or parallel, a higher degree of accuracy can be obtained. Use a resistor that is temperature stable.

AMPLIFIER BALANCE

The following procedure is recommended to balance the operational amplifiers (Amplifiers #1 through #4).

Refer to Figure 3.

1. Turn the AC POWER ON.

2. Connect each amplifier as a gain-of-10 amplifier with the 100 KΩ and 10 KΩ quick-connect resistors, as shown. Groups of quick-connect resistors and leads may be ordered from the Heath Company or assembled using the spring clips and sleeving supplied. See the Connecting Parts section on Page 11.

3. Connect a VTVM between the output of the amplifier and ground. Set the VTVM on the 1.5 volt DC range.

4. Set the FINE BALANCE control on each amplifier to the physical center of its range.

5. Turn the DC POWER switch to ON and allow the unit to warm up for 1/2 hour. Then adjust the COARSE BALANCE control of each amplifier for a reading as close to zero as possible on the VTVM.

6. Carefully adjust the FINE BALANCE control for an exact zero reading on the VTVM.

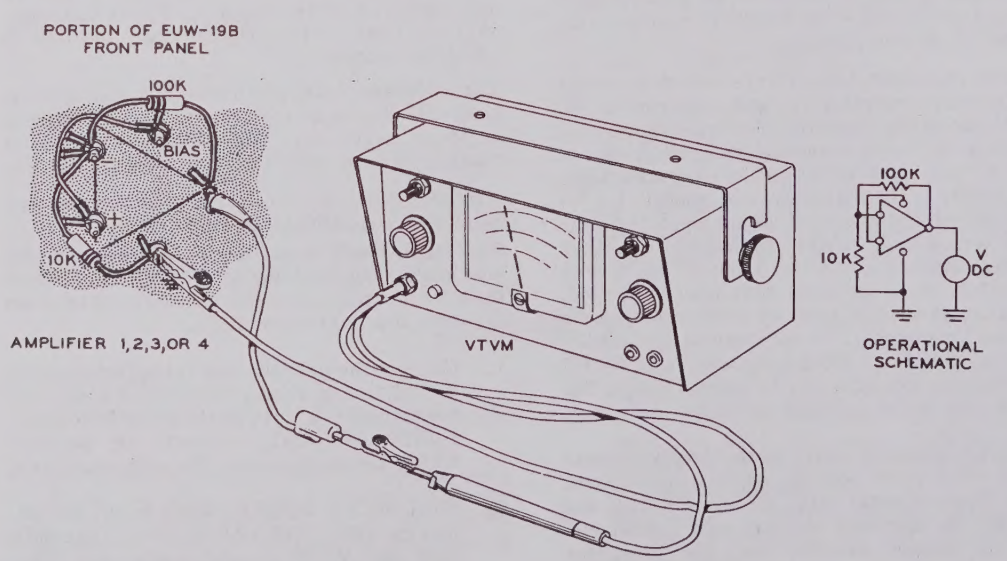


Figure 3

NOTE: If a VTVM with a voltage scale of less than 1.5 volts is available, use the lowest possible scale and adjust the FINE BALANCE controls for zero voltage.

7. The Amplifiers are now balanced. Unless a tube or other component is replaced, all future balance adjustments can be made with the FINE BALANCE control on each amplifier. Check the balance of the amplifiers from time to time when they are in use.

In most applications, the (-) input is at ground potential when the bias is properly adjusted. A simple way to check and adjust the bias while the Amplifier is in operation in a circuit is to measure the potential of the (-) input pin with respect to the ground (⏚) pin with a sensitive VTVM and adjust the bias for a reading of zero volts.

When a booster amplifier is used, connect the circuits as in Figure 4. Adjust the FINE BALANCE control of the Operational Amplifier to obtain a reading of zero volts at the output of the Booster Amplifier.

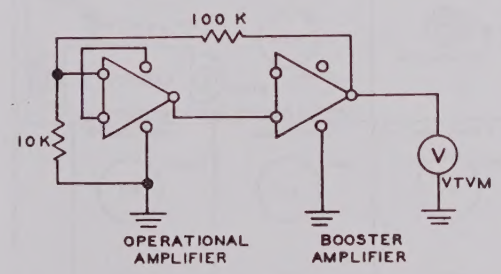


Figure 4

FOLLOWER AMPLIFIER

A follower amplifier is a unity-gain amplifier with a very high input impedance and a very low output impedance. It is very useful as an impedance matching, unloading, or decoupling amplifier where precise gain is required. An operational amplifier is wired as a follower amplifier by feeding the entire output signal back to the inverting input. A variable bias voltage is inserted in the feedback loop to adjust the follower for zero offset. The circuit is shown in Figure 5.

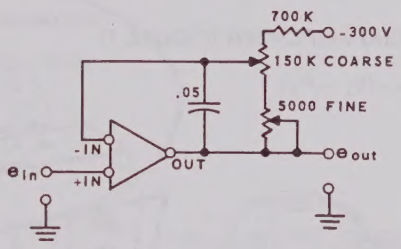


Figure 5

All four operational amplifiers in the System may be wired as followers. When the Amplifier No. 1 BIAS switch is in the Follower position, the Bias terminal for Amplifier #1 is wired as shown in Figure 5. In order to wire Amplifier #1 as a follower, it is only necessary to switch the bias and connect a lead between the Bias and the -In terminals as shown in Figure 6.

To wire amplifier #2, #3, or #4 as a follower, the bias circuit of Figure 5 must be wired externally and connected to the front panel terminals.

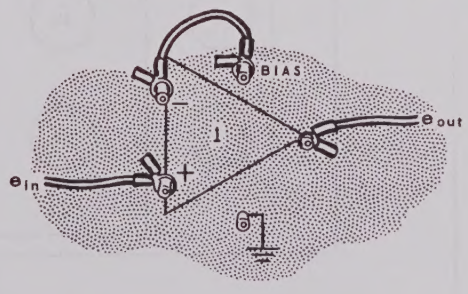


Figure 6

SAMPLE OPERATIONAL AMPLIFIER CIRCUITS

SUMMING AMPLIFIER (FIGURE 7)

$e_{out} = -(e_1 + e_2)$

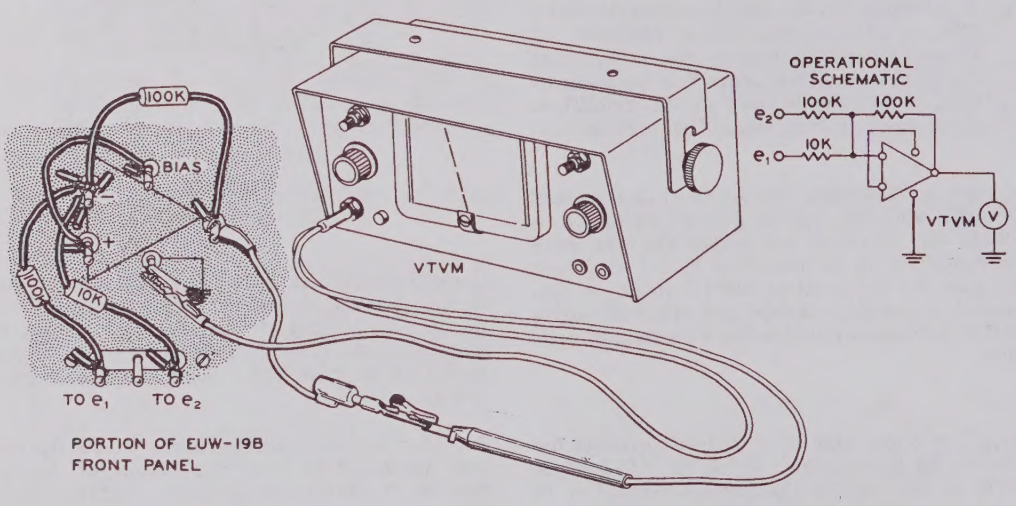


Figure 7

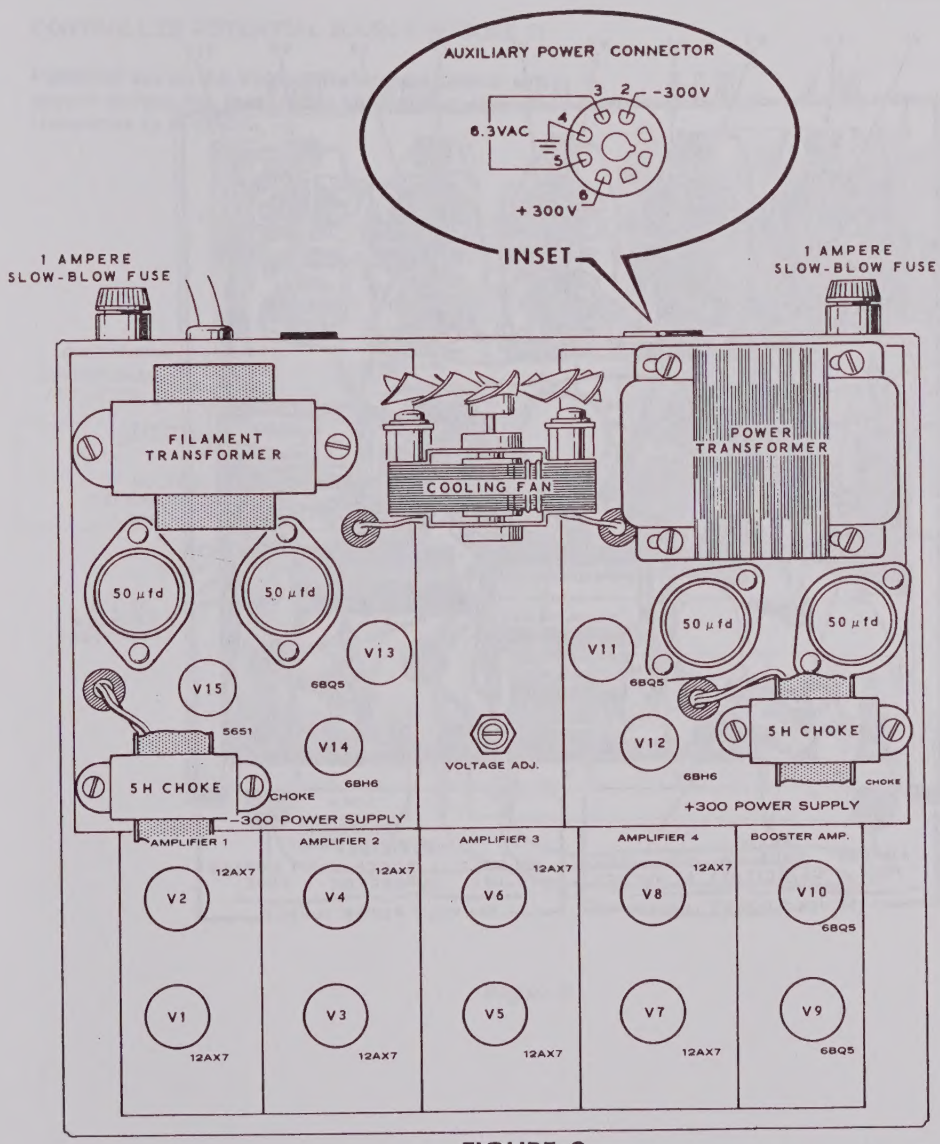
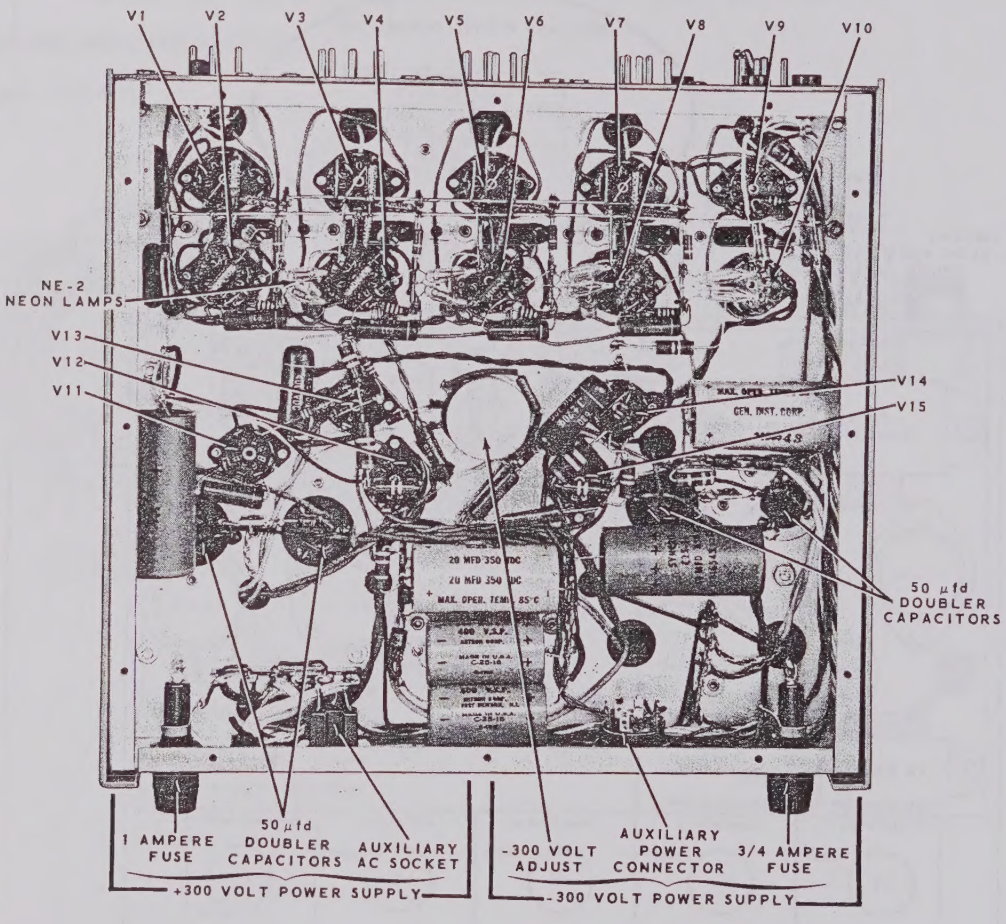

AUXILIARY POWER CONNECTOR
3
2
-300V
6.3VAC
4
5
6
+300V
INSET
1 AMPERE SLOW-BLOW FUSE
1 AMPERE SLOW-BLOW FUSE
FILAMENT TRANSFORMER
COOLING FAN
POWER TRANSFORMER
50 µfd
50 µfd
50 µfd
50 µfd
V13
6BQ5
V15
5651
V14
6BH6
V11
6BQ5
V12
6BH6
5H CHOKE
CHOKE
5H CHOKE
CHOKE
VOLTAGE ADJ.
-300 POWER SUPPLY
+300 POWER SUPPLY
AMPLIFIER 1
AMPLIFIER 2
AMPLIFIER 3
AMPLIFIER 4
BOOSTER AMP.
V2
12AX7
V4
12AX7
V6
12AX7
V8
12AX7
V10
6BQ5
V1
12AX7
V3
12AX7
V5
12AX7
V7
12AX7
V9
6BQ5

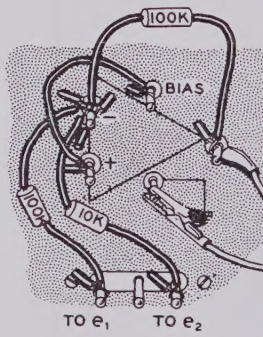
FIGURE 2



SAMPLE

SUMMING AMPLIFIER (

$e_{out} = -(e_1 + e_2)$



PORTION OF EUW-19B
FRONT PANEL

CONTROLLED POTENTIAL SOURCE (FIGURE 8)

Potential set on the Voltage Reference Source will appear across the load. Up to ±50 volts at ±20 milliamperes is available.

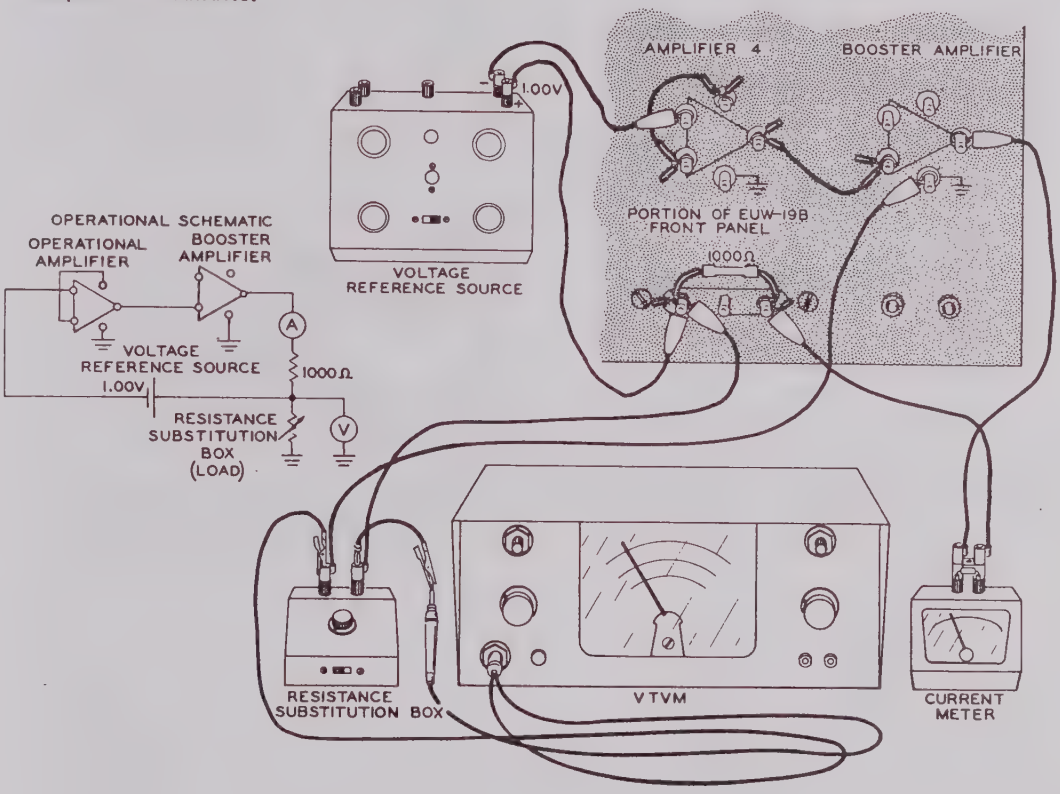


Figure 8

INTEGRATING AND DIFFERENTIATING CIRCUITS

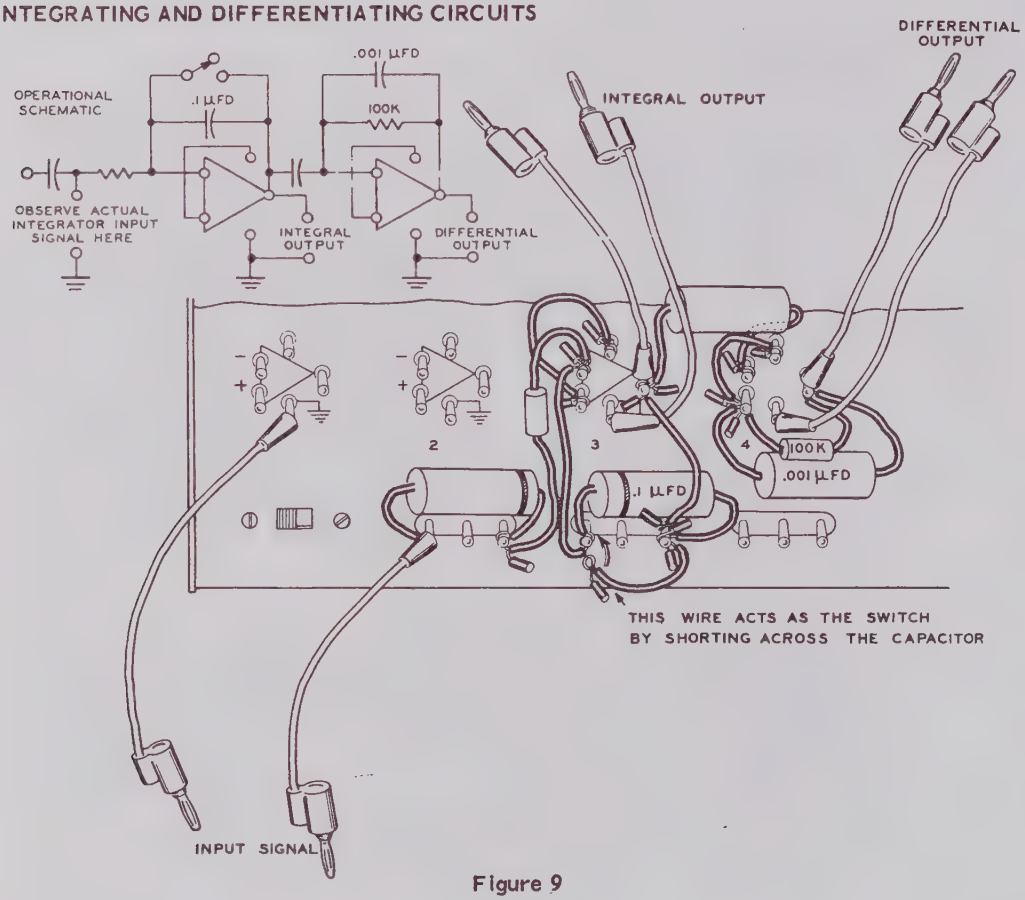


Figure 9

AUXILIARY POWER SOCKET

Regulated +300 volts and -300 volts can be obtained from the Auxiliary Power socket to operate auxiliary equipment. 20 milliamperes of current is available from each supply when the amplifiers are in operation. 60 milliamperes can be drawn from each supply if all of the amplifier tubes are removed. 6.3 volts AC is also available at 50 milliamperes with unit in operation, and at 3.2 amperes with all amplifier tubes removed.

CONNECTING PARTS

Spring clips are supplied to be installed on components. Figure 10 shows how one of the clips can be fastened to a resistor or capacitor lead. Use the following steps.

1. Cut some fiberglas lined sleeving to the same length as the lead. Put this sleeving over the lead.

2. Press the sleeving back toward the body of the resistor or capacitor, and fasten the end of the lead to one of the eyes in the clip.

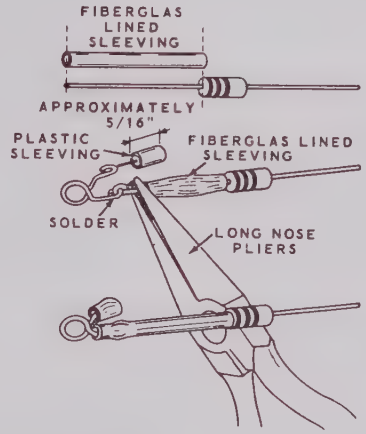


Figure 10

3. Hold the sleeving back with long-nose pliers and solder the clip and lead together.

4. Slide the sleeving over the soldered connection. Place a 5/16" length (appoximately) of plastic sleeving over the other eye of the clip.

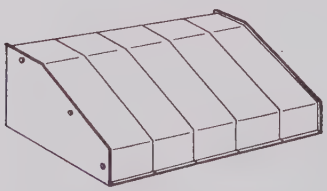
REPLACEMENT PARTS

This list includes only those parts which may be difficult to obtain locally, if replacement is required.

PART No.	DESCRIPTION
RESISTORS	
Metal Film-1/2 Watt, Temperature Stable	
2-213	240 KΩ
2-214	500 KΩ
2-216	1 megohm
2-217	2.2 megohm
Metal Film - 1 Watt, Temperature Stable	
2-52-1	100 KΩ
2-53-1	96,200 Ω
CAPACITORS	
20-118	15 μμf mica
21-5	20 μμf disc
21-13	500 μμf disc
21-48	.05 μfd disc, 50 V
23-3	.01 μfd tubular, 400 V
23-53	.1 μfd, 400 V
25-16	20 μfd electrolytic, 350 V
25-17	50 μfd electrolytic, 350 V
25-30	20-20 μfd electrolytic, 350 V
25-36	40 μfd electrolytic, 450 V
CONTROLS-SWITCHES	
11-69	150 Ω control
11-70	5000 Ω control

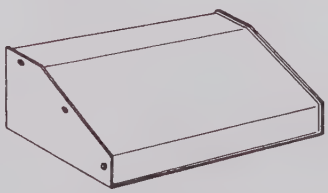
PART No.	DESCRIPTION
Controls-Switches (cont'd.)	
60-2	DPDT slide switch
61-1	SPST toggle switch
TUBES-LAMPS	
411-26	12AX7 tube
411-94	5651 tube
411-95	6BH6 tube
411-108	6BQ5 tube
412-11	Neon lamp, NE-2
412-15	Neon lamp, NE-2H
MISCELLANEOUS	
46-32	5 henry choke
54-128-24	Power transformer
54-129-24	Filament transformer
57-27	750 ma silicon rectifier, 500 PIV
260-37	Spring clip
413-10	Red pilot lamp lens
421-23	1 ampere slow-blow fuse
431-63	3-pin terminal strip (near bottom of front panel)
432-51	5-prong connector (Amplifier Input-Output connector)
346-1	Fiberglas sleeving
346-19	Sleeving
595-820	Manual

ACCESSORY PARTS



EUA-19-3

FIVE INDIVIDUAL PLUG-ON CHASSIS SHOWN BOLTED TOGETHER



EUA-19-1

FIVE-SOCKET PLUG-ON MODULE

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 15) and to the Block Diagram while reading the following description.

The Operational Amplifier System has an amplifier section that contains five amplifiers, and a power supply section with +300 volt and -300 volt regulated power supplies. The amplifier section has two kinds of amplifiers. Amplifiers #1, #2, #3, and #4 are difference amplifiers with both inverting and noninverting inputs available. Amplifier #1 bias can be switched for follower application. Amplifier #5 is a booster amplifier for power applications, such as driving motors, etc.

AMPLIFIER SECTION

Inverting Amplifier

Since inverting Amplifiers #2, #3, and #4 have exactly the same circuits, only amplifier #2 will be described.

The signal going to the input of amplifier #2 is connected to the grid of either V3A or V3B, which are wired in a difference amplifier circuit. For inverting amplifier operation, the signal is connected to the grid of V3A, and the bias terminal is connected to the grid of V3B. This places the Balance control in the circuit to adjust the bias on V3B for zero volts between the output and ground pins of the amplifier when the input voltage is zero.

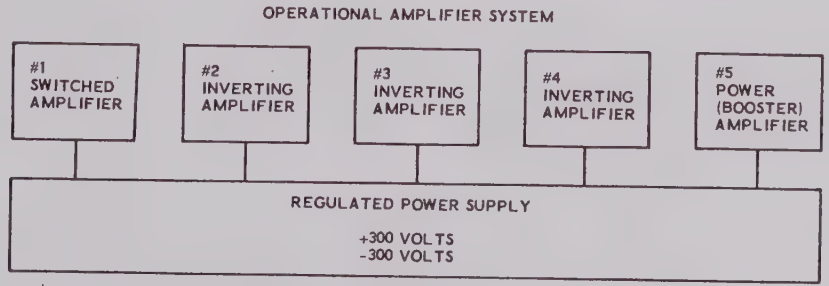
The signal, which is proportional to the difference in potential between the -IN and +IN terminals, is coupled from the plate of V3B through a resistive voltage divider to the grid of V4A, where it is amplified further. From the plate of V4A the signal is coupled through two neon lamps to the grid of V4B. For noninverting, or difference, operation, a signal is connected the grid of V3B.

The neon lamps keep a constant voltage between the plate of V4A and the grid of V4B; as a result, all voltage changes that appear at the plate of V4A appear across the 2.2 megohm grid resistor. A .01 μfd capacitor couples higher frequency signals from V4A to V4B. The 1 megohm resistor at the grid of V4B prevents an oscillation from occuring between the .01 μfd capacitor and the two neon lamps.

The output signal is coupled directly from the cathode of cathode follower V4B. A 240 KΩ resistor returns positive feedback from the cathode of V4B to the cathode of V4A. Correct operating voltages for these cathodes are supplied by a voltage divider consisting of 120 KΩ, 240 KΩ, and 10 KΩ resistors between -300 volts and ground.

Amplifier #1

In the Normal switch position, amplifier #1 bias is appropriate for an inverting amplifier, and the circuit is exactly the same as the circuits of Amplifiers #2, #3, and #4.



BLOCK DIAGRAM

In switch position 2, the Follower amplifier position, the Balance adjust voltage divider is connected between -300 volts and the cathode of V2B. The arm of the Balance adjust control is connected externally to the grid of tube V1A. The input terminal is connected to the grid of V1B. This allows the amplifier to be balanced at the grid of V1A when the input signal is connected to V2B. By using temperature-stable metal film resistors in the critical parts of the amplifier circuits, reliable operation and minimum drift are obtained.

Booster Amplifier

The booster amplifier is used to supply additional power when the current output of one of the other amplifiers is insufficient. Normally, the output of the other amplifier is connected to the input of the booster amplifier. The booster amplifier is noninverting.

A positive (+) signal at the input terminal of the booster amplifier would be applied to the grid of V9, causing the current through V9 to increase. The increased current would flow to the cathode of V9 through the load instead of flowing through V10. The current in V10 does not change significantly, since any current increase also increases the bias voltage across the 470 Ω resistor.

A negative voltage at the grid of V9 causes the current in V9 to decrease. The current in V10 still does not change significantly, thus the difference current between the currents of V9 and V10 now flows from V10 through the load.

POWER SUPPLY SECTION

The power supply section may be divided into three general parts: The regulated +300 volt power supply, the regulated -300 volt power supply, and the filament supply. The +300 volt supply and the -300 volt supply use the same circuit, except the +300 volt supply does not use a voltage regulator tube. For ease in explaining the circuit, only the +300 volt supply will be described.

The primary windings of the power transformer and the filament transformer may be connected in either of two ways. For 105-125 volt operation, connections A (see Schematic) are made at the terminal strips that connect the transformer leads. For 210-250 volt operation, only connection B is made. These alternate connections place the primary windings in parallel (for 120 VAC input) or in series (for 240 VAC input) to match the line voltage.

Power is supplied from the AC line to the primary of the filament transformer through the AC Power switch and a 1 ampere slow-blow fuse. A neon lamp in the primary indicates when power is applied to this transformer. The three secondary windings of this transformer supply filament current to all tubes.

Power is supplied from the AC line to the primary of the power transformer through the DC Power switch and a 1 ampere slow-blow fuse. A neon lamp indicates when DC power is applied to the unit. The fan motor is also controlled by the DC Power switch and runs only when the DC power is turned on.

Voltage-Doubler Section

DC+ voltage is supplied from a voltage-doubler circuit that consists of two silicon diodes and two 50 μfd electrolytic filter capacitors. Each half of the 60 Hz (cps) sine wave from the power transformer charges up one of the 50 μfd capacitors to its peak voltage. The peak voltage charges on these two 50 μfd capacitors are added together. Ripple is filtered by the two 50 μfd capacitors, and also by the choke and the 40 μfd electrolytic capacitor. DC voltage from this filter is then applied to the regulator circuit.

Regulator Circuit Operation

Positive DC voltage from the filter is connected to the plate of series tube V13. Series tube V13 acts as a large variable resistor in series with the positive DC output of the power supply. The larger this variable resistor becomes, the smaller the output voltage will be.

The resistance of the 6BQ5 series tube, V13, is controlled by the voltage at its grid, and the voltage at the grid is controlled by the current flowing through the 6BH6 control tube and the 220 KΩ 1 watt resistor.

The current flowing in the 6BH6 tube is controlled by the voltage between its grid and cathode. The cathode voltage is held at a constant value by the 5651 reference tube and the grid voltage is controlled by the voltage at the arm of the Voltage Adjust control.

The +300 volt power supply is also controlled by the Voltage Adjust control. A portion of the -300 volt supply is connected to V12, the control tube for the +300 volt supply. When the -300 volt supply is changed by the Voltage Adjust control, the grid voltage at V12 changes and adjusts the +300 volt output.

The screen of series tube V13 has its own DC supply voltage which holds the screen voltage at a constant value with respect to the cathode of the tube. This voltage is obtained from a separate winding on the power transformer; it is then rectified by the silicon diodes. Ripple is removed by a filter that consists of a 3300 Ω 1 watt resistor and two 20 μfd electrolytic capacitors.

REGULATOR EXAMPLE 1. An increase in the load current would cause the DC output (+300 volts) voltage to begin to decrease. This voltage decrease would also decrease the voltage at the grid of the 6BH6, decreasing the current through the 6BH6. The current decrease causes the plate voltage of the 6BH6, and therefore the grid voltage of the 6BQ5, to increase (become less negative).

A less negative grid voltage causes the resistance of the 6BQ5 to decrease with the result that less voltage is dropped across it, and the DC output voltage increases to its former value. This whole series of changes, which actually occur in a fraction of a second, are reversed if the load begins to decrease.

REGULATOR EXAMPLE 2. An increase in the input power line voltage would cause the power transformer voltages to increase. Therefore, the DC voltage from the voltage-doubler circuit and the DC output voltage would begin to increase. From this point on, the regulating action is the same as in Example 1, except that all of the controlling voltages will go in the opposite directions. As a result, the resistance of the 6BQ5 series tube would increase, and the DC output voltage would decrease to its former value.

Auxiliary Power Connector

The regulated (+300 volts) output voltage from the cathode of V11 is connected to pin 6 of the Auxiliary Power connector. DC- of the +300 volt supply, DC+ of the -300 volt supply, and chassis ground are all connected to pin 4 of the Auxiliary Power connector. -300 volts is connected to pin 2 of the Auxiliary Power connector. These connections may be used instead of the jacks on the front panel to adjust the +300 and -300 volt power supply to its correct output voltages.

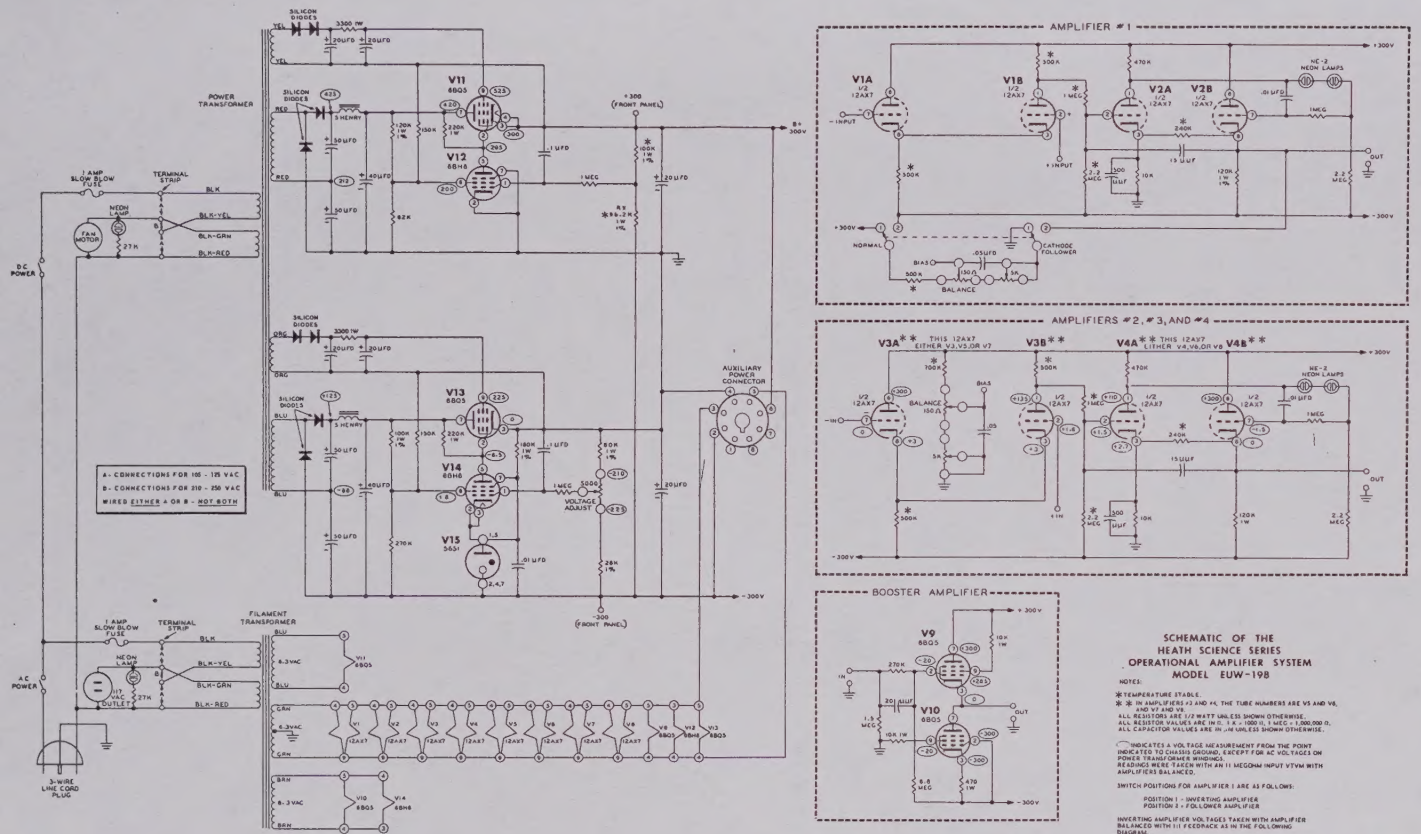
The 6.3 volt AC filament voltage is connected to pins 3 and 5 of the Auxiliary Power connector.

REPLACEMENT PARTS PRICE LIST

'ART No.	PRICE Each	DESCRIPTION
:ESISTORS		
Aetal Film-1/2 Watt, Temperature Stable		
-213	.20	240 KΩ
-214	.20	500 KΩ
-216	.20	1 megohm
-217	.20	2.2 megohm
Aetal Film-1 Watt, Temperature Stable		
-52-1	.55	100 KΩ
-53-1	.55	96,200 Ω
:APACITORS		
0-118	.15	15 μμf mica
1-5	.10	20 μμf disc
.1-13	.10	500 μμf disc
1-48	.15	.05 μfd disc, 50 V
3-3	.15	.01 μfd tubular, 400 V
3-53	.20	.1 μfd, 400 V
5-16	.80	20 μfd electrolytic, 350 V
5-17	1.05	50 μfd electrolytic, 350 V
:5-30	1.05	20-20 μfd electrolytic, 350 V
:5-36	1.00	40 μfd electrolytic, 450 V
:ONTROLS-SWITCHES		
1-69	.65	150 Ω control
1-70	.90	5000 Ω control
0-2	.25	DPDT slide switch
1-1	.80	SPST toggle switch
TUBES-LAMPS		
11-26	1.20	12AX7 tube
11-94	1.80	5651 tube
11-95	1.40	6BH6 tube

PART No.	PRICE Each	DESCRIPTION
Tubes-Lamps (cont'd.)		
411-108	1.15	6BQ5 tube
412-11	.20	Neon lamp, NE-2
412-15	.15	Neon lamp, NE-2H
MISCELLANEOUS		
46-32	1.75	5 henry choke
54-128-24	7.00	Power transformer
54-129-24	5.00	Filament transformer
57-27	.60	750 ma silicon rectifier, 500 PIV
260-37	.05	Spring clip
413-10	.10	Red pilot lamp lens
421-23	.30	1 ampere slow-blow fuse
431-63	.10	3-pin terminal strip (near bottom of front panel)
432-51	.15	5-prong connector (Amplifier Input-Output connector)
346-1	.05/ft	Fiberglas sleeving
346-19	.05/ft	Sleeving
595-820	N/C	Manual

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Selling prices elsewhere in U.S.A. may be slightly higher to offset transportation and local taxes. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.



SCHEMATIC OF THE
HEATH SCIENCE SERIES
OPERATIONAL AMPLIFIER SYSTEM
MODEL EUW-19B

NOTES:

*TEMPERATURE STABLE.

** IN AMPLIFIERS #2 AND #4, THE TUBE NUMBERS ARE V5 AND V6, AND V7 AND V8.

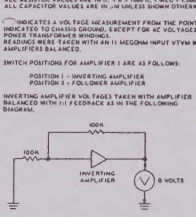
ALL RESISTORS ARE 1/2 WATT UNLESS SHOWN OTHERWISE.
ALL RESISTOR VALUES ARE IN Ω. 1 K = 1000 Ω, 1 MEG = 1,000,000 Ω.
ALL CAPACITOR VALUES ARE IN μF UNLESS SHOWN OTHERWISE.

( ) INDICATES A VOLTAGE MEASUREMENT FROM THE POINT INDICATED TO CHASSIS GROUND, EXCEPT FOR AC VOLTAGES ON POWER TRANSFORMER WINDINGS.
READINGS WERE TAKEN WITH AN 11 MEGOHM INPUT VTVM WITH AMPLIFIERS BALANCED.

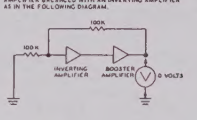
SWITCH POSITIONS FOR AMPLIFIER 1 ARE AS FOLLOWS:

POSITION 1 - INVERTING AMPLIFIER
POSITION 2 - FOLLOWER AMPLIFIER

INVERTING AMPLIFIER VOLTAGES TAKEN WITH AMPLIFIER BALANCED WITH 1:1 FEEDBACK AS IN THE FOLLOWING DIAGRAM.



BOOSTER AMPLIFIER VOLTAGES TAKEN WITH BOOSTER AMPLIFIER BALANCED WITH AN INVERTING AMPLIFIER AS IN THE FOLLOWING DIAGRAM.



MP MASTER
MA22741